SILVER-LEAF DISEASE, III

(INCLUDING OBSERVATIONS UPON THE INJECTION OF TREES WITH ANTISEPTICS)

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1. INTRODUCTION.

The present paper contains the results of investigations on silver-leaf disease which are a continuation of those previously described by one of us (1, 2) in earlier numbers of this periodical.

Some time ago it was thought desirable to duplicate as far as possible in different localities the experiments conducted on this disease. Hence most of the experiments described in this paper have been carried out both at Cambridge and at the John Innes Horticultural Institution, Merton.

As before, the experimental work at Cambridge has been done on the University Farm by permission of the School of Agriculture, and in the Botanic Garden by courtesy of Mr R. I. Lynch. The trees used at Cambridge were mostly provided by a grant from the Development Fund to which reference was made in earlier papers of this series.

Few papers on silver-leaf disease have appeared since the publication of the paper by one of us (2) in 1913, the most noteworthy being that by Smolak (9), to which it is necessary to devote some attention before our own results are considered.

As pointed out in the *Annals of Applied Biology* (4), he has inadequately represented the views on silver-leaf expressed by one of us in earlier papers. For instance, Smolak states that "according to the investigations of Brooks the basidiomycete *Stereum purpureum* is the cause of silver-leaf disease," whereas the view put forward was that "silver-leaf disease is a general pathological phenomenon, one cause of which is the fungus *Stereum purpureum*," a view which, it may be said at once, we see no reason to change.

Smolak's observations on the cytology of silvered leaves are interesting, but there is no reason why the changes in the cell contents described by him should not be attributable either directly or indirectly to *Stereum purpureum* present in woody tissues below, even though the influence of a specific enzyme carried up in the transpiration current as suggested by Percival (7) be excluded. Smolak apparently finds it difficult to conceive of action at a distance in the association of *Stereum purpureum* with silver-leaf disease, and suggests (*loc. cit.* p. 154) that silvering is an autolytic action. The presence of the fungus in the woody tissues of the stem may, however, cause some chemical or physical disturbance in the transpiration current, which, upon being felt in the leaves above, causes silvering. Such a disturbance in the transpiration current may either directly bring about the change or indirectly do so by liberating some other substance in the cells of the leaves to which the change is immediately due. Where silvering is not due to *Stereum purpureum* the phenomenon may be caused by the liberation of the same substance in response to other, at present unknown conditions, or may be otherwise brought about by these particular conditions. Even when the primary agent in silvering is *Stereum purpureum*, the last links in the chain of cause and effect are not yet known.

The cytological peculiarities of silvered leaves described by Smolak are possibly incipient stages in the death of the cells slowly induced by a disturbance in the normal physiology of the tissues. No statement is made as to the age of the silvered leaves examined by him.

Smolak also adds that "perhaps the inoculation experiments hitherto carried on have been too few or possibly they are not yet complete enough to decide the relation of *Stereum* to this disease," but in view of the very numerous successful inoculation experiments carried out by

Percival (7), Pickering (8), Güssow (5), and Brooks (1, 2), including many pure culture inoculations performed by the last named, this statement is surprising. Later in the present paper it will be shown that all Koch's postulates have now been carried out and fructifications of *Stereum purpureum* have developed on trees which were inoculated with pure cultures of the fungus. The suggestion of Smolak that silver-leaf may be due to bacterial infection is not supported by definite evidence.

As regards the physical reasons for the appearance of silvering, there seems to be little disagreement between Smolak's views and ours. We still consider that by far the greater part of the peculiar appearance of plum leaves in the earlier stages of silvering is due to the formation of abnormal air spaces below the upper epidermis, whereby the character of the light normally reflected is changed. If the upper epidermis of a plum leaf which has not been long silvered is stripped off, the underlying mesophyll is dark green in colour and is indistinguishable to the naked eye from the mesophyll of a normal leaf. The mesophyll of plum leaves which have been silvered a long time on the other hand does appear lighter green in colour than that of healthy leaves viewed in the same manner. The individual mesophyll cells of young silvered leaves examined freshly under the microscope, cannot be distinguished from corresponding cells of a normal leaf, although leaves in which the silvering is of long standing eventually show a considerable number of cells in which the chloroplasts are fading and disorganising. It is noteworthy that even in a normal plum leaf a few of the cells often show disorganised chloroplasts long before the onset of autumn. Smolak did not examine the contents of silvered cells in the fresh condition.

2. FURTHER OBSERVATIONS UPON THE OCCURRENCE AND INCIDENCE OF SILVER-LEAF.

The leaves of a plum tree affected by *Stereum purpureum* often show silvering both at and directly after the time of unfolding in the spring, but sometimes only the first formed leaves on a particular shoot exhibit the affection. The same is often true of shoots belonging to second or "midsummer" growth later in the year. Although leaves are sometimes completely silvered at the time of unfolding many leaves subsequently become silvered which were normal while expanding. Smolak states (*loc. cit.* p. 141) that "the spreading of the silvering always began first of all on and around the vascular bundles (veins)." As the network of veins in a plum leaf is very intricate and permeates almost the whole of the leaf, this statement does not appear to be clear, but if the principal

veins are meant, it must be pointed out that silvering often proceeds from the leaf margin instead of from one of the larger vascular bundles. With parti-silvered leaves the boundary between the normal and abnormal parts may be sharply defined and may remain fixed, but by marking the boundary with Indian ink, an extension of the silvered area can sometimes be observed.

Since the publication of Brooks' paper on silver-leaf in 1913 (2), numerous examples of silvered foliage occurring naturally in other plants have been seen. Mention will be made first of those in which silvering was associated with the presence of *Stereum purpureum*.

In July, 1913, our attention[1] was called to a number of silvered sloe trees amongst healthy ones in a field hedge near Cambridge. In one of the affected trees some of the branches were dying back. Sections of branches bearing silvered leaves showed sectors of discoloured wood, containing hyphae as described (1, 2) for silvered branches of cultivated plums. The affected leaves exhibited the usual characters of silvered foliage, the tendency of the mesophyll cells to fall asunder being very pronounced. During October of the same year fructifications of *Stereum purpureum* developed in abundance on the dead portions of this silvered tree.

During the summer of 1913 an apricot tree growing against a wall was seen to be silvered and some of its branches were dying back. The leaves showed the usual characters of silvered foliage and the branches that were dying back contained discoloured zones of wood as in silvered plum trees. The silvered branches continued to die during the summer and fructifications of *Stereum purpureum* arose on them during the autumn.

Silvering of laburnum trees associated with *Stereum purpureum* was described in the previous paper of this series (2) and it suffices to say that several other silvered trees of the same kind have since been seen associated with this fungus. The frequency of silvering in laburnums in private gardens is probably due to the pruning to which they are often subjected, the wounds so made affording abundant opportunity for the entrance of the wound parasite, *Stereum purpureum*.

During 1915 many silvered shoots were seen arising from stools of poplar trees and on each of the five stumps from which such shoots arose, *Stereum purpureum* was growing abundantly. These stools formed part of a row of poplars, the intact trees of which showed normal

[1] We are indebted to Mr F. G. Tutcher, Sub-Inspector of the Board of Agriculture and Fisheries for pointing out these trees to us.

foliage. In addition to the shoots arising from the stumps, one sucker arising some distance away from them was silvered. Affected leaves were examined during September and fresh sections showed 20–50 per cent. of the palisade cells with disorganising chloroplasts, the sections as usual showing a marked tendency to fall asunder. It is not known how long these leaves had been silvered.

The only other record of silver-leaf in poplars as far as can be ascertained occurs in the report of the Scientific Committee of the Royal Horticultural Society for 1913, when one or two of a number of leaves of a poplar attacked by *Ascomyces* (*Taphrina*) *aureus* submitted to the Committee were said " to show the silvery appearance characteristic of the attack of *Stereum purpureum* as seen in plums."

As regards other plants referred to in the previous paper (2), in which silvering was associated with *Stereum purpureum*, it may be stated that in hundreds of plum trees, especially Victorias, seen in different parts of the country, the association of this fungus with dying silvered branches has been invariable. The character of the soil appears to have little influence on the incidence of the disease in plums, which seems to be as common on soils amply provided with lime as it is where this constituent is less abundant. In addition to Victoria, the variety Czar is also very susceptible to silver-leaf in some districts, but other varieties, e.g. Monarch, Early Rivers, Pond's Seedling, and Pershore are only occasionally attacked. The relative immunity of the large mature areas of the last-named variety in the Evesham district is very striking. A belief prevails there that the variety Victoria worked on the Pershore stock instead of on other stocks generally used, e.g. Brampton, is thereby rendered relatively immune from silver-leaf disease. There is, however, no definite evidence yet that this belief is well founded and certain inoculation experiments described below do not support it. Occasionally *Stereum hirsutum* as well as *Stereum purpureum* is seen on silvered plum trees, but as described under the heading of inoculation experiments, the former cannot be considered a cause of silver-leaf.

With silvered apple trees, the presence of *Stereum purpureum* is by no means so constant as in plums except possibly in regrafted trees.

A silvered cherry tree near Cambridge came under observation in 1913, several of the diseased branches containing discoloured wood, but it is not known whether *Stereum purpureum* subsequently developed upon it. Another silvered cherry tree was seen in the North of England in 1916. As will be shown later, silvering has been induced in old cherry trees by inoculation with *Stereum purpureum*. Some cherry trees about

ten years old which were cut back in 1915, showed silvered shoots arising near the unprotected extremities during 1916. Examination showed that the portions bearing the silvered shoots contained much discoloured wood whereas in parts similarly cut back and bearing healthy branches there was very little discolouration of the tissues.

Several additional silvered red currant bushes have been seen on which *Stereum purpureum* developed.

Silver-leaf is of common occurrence in the Portugal laurel and it has often been seen in connection with dying back of the branches. Other observers have seen *Stereum purpureum* in association with the disease on these plants.

On the other hand, examples of trees killed by *Stereum purpureum* with which the phenomenon of silvering was not associated, have been seen. Since 1913, when brief reference (2) was made to this possibility, certain birch and plane trees growing in gardens, after being severely cut back, have been rapidly killed by this fungus without silvering of the leaves being evident.

In 1913 (2) it was pointed out that several examples of silvered foliage had been seen with which there was no connection with *Stereum purpureum*.

Since that year numerous other examples of silvered foliage have come under observation which could not have been induced by *Stereum purpureum*, and with which there could have been no connection.

In 1913 (2) the silvering of certain batches of seedling plums was described, and it was pointed out that, though this affection was strictly comparable with the silvering of adult trees, it was certainly not attributable to *Stereum purpureum* as no fungus mycelium was found in the tissues.

Since then several other lots of seedling plums and other seedling plants have been examined and many of them have shown silvering. The affection, if it is really an affection in these cases, is capricious in occurrence. Of batches of seeds treated apparently in the same manner, some may give rise to silvered seedlings while others develop normally.

The subsequent history of the silvered plum seedlings raised by Mr W. O. Backhouse and described in 1913 (2) will first be given. Before planting out in the open during May, 1912, several of these silvered seedlings were examined microscopically and although sections of the leaves showed the usual tendency to fall asunder, no trace of fungus attack could be found in stem, leaf, or root. During the summer and early autumn of 1912, the condition of these silvered seedlings

seemed to show a gradual improvement, i.e. their foliage appeared to become more normal in appearance. During February, 1913, these seedlings, then about a foot high, were cut down in order to be used for scions. In May, 1913, about fifty of these 400 Victoria seedlings were still silvered and by 1914 only about ten remained silvered, so it is clear that these plants gradually grew out of the affection.

While visiting the Agricultural Research Station at Long Ashton, Bristol, during July, 1913, Professor Barker called the attention of one of us to the presence of silver-leaf in seedlings of certain kinds of *Ribes*, *Rubus*, and *Prunus*. These seedlings had been planted out in May of the same year in soil which had been broken up from grass land two years previously and had not been manured. The following is a summary of the observations made at the time of the visit:

Red Currant (*Raby Castle*).
Silvering common but more marked in old than in young leaves.

Red Currant (*Sweet Red*).
Plants appear to be growing out of silvering.

Red Currant (*Ogden's*).
No sign of silver-leaf.

White Currants (*White Dutch Cut Leaf*).
Plants appear to be growing out of silvering.

Rubus innominatus Kuntzeanus.
Numerous plants with silvered foliage.

Loganberry.
Silvering present but not conspicuous.

Prunus spinosissimus.
One of the five plants was markedly silvered.

It was not possible to examine these silvered plants microscopically, but to the naked eye they appeared to be typically silvered, although most of them were growing out of the affection.

After treatment in the usual manner[1] other batches of plum seeds of different varieties (Victoria, Monarch, Greengage) gathered in 1913

[1] These seeds were treated in the following manner: the plum stones were placed in damp soil as gathered and when the collection was complete the stones were washed and then immersed in shallow boxes of sand previously dry heated to 100° C. The boxes were then placed in a cold frame and kept damp. Early in January the seeds were taken from the stones and then planted in soil which had been treated with toluol and placed in a greenhouse from which frost was excluded. Under these conditions germination proceeded.

were sown under varying conditions (in ordinary soil, in manured soil, in sand, and at different distances apart) during the winter of 1913–14, but none of these seedlings showed characteristic silvering although the foliage of a small number developed a peculiar leaden pallor. Some of the Victoria seeds used in this series were obtained from heavily silvered trees. Large numbers of red currant seedlings (from seed gathered in 1913) grown in boxes also developed normal foliage.

Other seedlings of various kinds grown under similar conditions by Mr G. O. Sherrard at the John Innes Horticultural Institution showed different results. Thus several seedlings of the following varieties of plums, Denniston's Superb, Early Transparent, and Gisborne showed silvered foliage, and nearly all the seedlings of loganberry and "Phenomenal Berry" possessed silvered foliage. On the other hand seedling apples and nectarines had normal foliage. The seedling *Rubi* were planted out in the open and showed a considerable recovery by the autumn.

These observations show that silver-leaf occurs commonly but irregularly in certain seedling plants notably plums, and species of *Rubus*. In these cases the silvering does not appear to be of pathological significance as the seedlings grow out of it in time. Nothing is yet known as to the cause of silvering in these seedling plants but our observations indicate that it is not due to a parasitic organism.

It was pointed out in 1913 (2) that plants of the white dead nettle with silvered foliage had been observed, and since then we have seen, during the latter part of the winter and early spring, many kinds of herbaceous plants with silvered foliage including *Lamium purpureum*, *Lamium amplexicaule*, *Veronica agrestis*, *Raphanus sativus*, *Urtica dioica*, *Plantago major*, rhubarb, and *Primula spp.* Mr G. Lamb writing in the *Gardener's Chronicle* for November 15th, 1913, recorded silvering of tomato foliage.

Several of the above plants have been microscopically examined by us and like the white dead nettle described in 1913 showed the typical characters of silvering. In these herbaceous plants there appears to be no regularity in the distribution of silvered leaves upon an individual plant, some branches bearing silvered leaves and others normal leaves. Fresh sections of a silvered leaf of *Lamium purpureum* showed no noticeable difference as regards the chloroplasts from those of a healthy leaf, although the epidermis was loose and there was the usual tendency of the mesophyll cells to fall asunder.

Two other examples of silver-leaf may be noted. Mr F. J. Chittenden

of Wisley informed one of us in 1913 that he had seen "a piece of a *Lonicera* (? *japonica*) with foliage showing all the characteristics of silver-leaf."

In 1914 one of us saw a single elm leaf on a small branch arising about seven feet up the trunk of a large tree, the middle of which was markedly silvered with the exception of some dark green flecks although the margin was either dark green or white. Other leaves of the same branch showed variegation but not silvering.

Finally, a few other leaf conditions may be noted, which, though not silver-leaf in the sense described above, simulate it closely.

While one of us was in Malaya during 1914 a branch of the Borneo camphor tree (*Dryobalanops aromatica*) came under observation which appeared as if silvered. The foliage of this plant is normally dark green but this branch had been severed from the tree and had been lying exposed to the sun for a few hours, after which the foliage appeared to be silvery. The leaves of the plant are too stiff to wilt and it seemed as if the upper epidermis had broken away from the mesophyll, thus allowing air to accumulate below the epidermis and so altering the character of the reflected light.

In the *Journal* of the Board of Agriculture for 1913 one of us(3) recorded the occurrence in the south of France of several kinds of shrubby plants, notably *Arbutus unedo*, *Myrtus communis*, *Viburnum Tinus*, with "silvery" foliage in contrast to the dark green leaves which these plants usually possess. Large numbers of these "silvery" plants were seen in irregular groupings, and on casual examination one would have certainly declared that these plants were silvered. Careful observation of leaves in an intermediate condition showed, however, that the "silvery" appearance was due to innumerable punctures of the epidermis by some insect, the character of the light reflected from these leaves being changed in consequence. In this country pea Thrips sometimes affects the pods in a somewhat similar manner.

3. INOCULATION EXPERIMENTS.

(*a*) *Experiments with plum trees.*

Large numbers of inoculation experiments, in addition to those described in previous papers of this series have been performed, especially with *Stereum purpureum*.

During 1911–12 certain inoculations with spores of *Stereum purpureum* were successfully carried out for the first time. Other spore

inoculations performed in a somewhat similar manner since then have given negative results. Thus branches of young Victoria plum trees were snapped across and after being left in this condition for some months, spores were inserted in the wounds without inducing silvering. Other branches were cut off to within two inches of the main stem and after leaving the ends exposed for various periods, spores were inserted, also with negative results.

Inoculations with spores of *Stereum purpureum* carried out, however, under conditions more favourable for infection have nevertheless been followed by silvering of the foliage in a considerable number of cases. The method of inoculation was as follows:

The main stem of a young healthy plum tree was cut back, and a little above the exposed surface a sporophore of *Stereum purpureum* was suspended from a pin after an interval during which the surface was left open to the weather or protected from it by means of a tube. A wad of damp cotton wool was placed over the sporophore to cause it to deposit spores freely, and the whole was enclosed in a glass tube fastened to the top of the stem by means of plasticine. With this arrangement, a heavy spore deposit fell on the end of the stem under conditions favourable for germination and infection. The experiment was varied in different ways—the end of the stem was sawn and covered with gas tar or Stockholm tar in some cases, in others the sawn or smoothed surface was left without treatment by an antiseptic. The following are details of the experiments carried out during 1913–14.

(1) The main stem of a standard Victoria tree 3–4 years old was cut back with a saw to within two feet of the ground on December 2nd, 1913, and the surface covered with gas tar. This remained exposed until January 31st, 1914, when a sporophore of *Stereum purpureum*, taken from a silvered plum tree, was placed over it and covered with a sterilized tube as described above. The fungus was removed two days later and the tube replaced. On May 13th a branch arising an inch below the inoculated surface, was heavily silvered although other branches below this were normal. By July other branches had become silvered and by the middle of September the whole tree was affected.

(2) A standard Czar, 3–4 years old, treated as in (1) except that the cut curface was left untouched. On May 13th, 1914, a branch arising $2\frac{1}{2}$ inches below the place of inoculation was silvered and the cut surface was gumming and covered with a greyish mycelium. Silvering did not extend much in this tree, only one other branch becoming affected before the autumn.

(3) A standard Czar, 3–4 years old, treated as in (1) but the cut surface was covered with Stockholm tar. On May 13th, 1914, a branch 4½ inches below the cut end was silvered although a branch three inches nearer was normal. Silvering did not progress further during the summer.

(4) A standard Czar, 3–4 years old, treated as in (1) but the cut surface was made smooth with a knife and left exposed until inoculation. On May 13th, 1914, silvering was evident on a branch 1½ inches below the cut surface which was gumming. Silvering spread during the summer until nearly the whole tree was affected.

(5) A standard Czar, 3–4 years old, was cut back with a saw December 2nd, 1913, and left untreated. Inoculation with sporophore material of the same gathering was not performed until March 2nd, the fungus being removed and the tube replaced the following day. This tree remained unsilvered.

(6) As in (5) but the cut surface was covered with gas tar. The tree remained unsilvered.

(7) As in (5) but the cut surface was covered with Stockholm tar. The tree remained unsilvered.

(8) On December 13th, 1914, the main stem of a standard Victoria tree 3–4 years old, was cut back with a saw, under sterile conditions, to within two feet six inches from the ground, and the cut surface was immediately covered with a sterile tube embedded in a collar of plasticine. A sporophore of the same gathering as before was inserted on March 2nd, 1914, and was removed the following day, the tube being replaced. In this experiment and in the next two, the inoculations were carried out under conditions as sterile as possible. On May 13th silvering was apparent in two branches eleven and eighteen inches respectively from the cut surface which was gumming. Other branches nearer the cut surface but with a different orientation were unsilvered and remained so throughout the summer.

(9) As in (8) except that the cut surface of the main stem was made smooth with a sterile knife. On May 13th two branches about eight inches below the cut surface were silvered, although two branches nearer the top were normal. By the first week of June all branches showed some silvering which became more marked as the season advanced.

(10) As in (8) except that the upper part of the main stem was half sawn, half broken across. On May 13th some of the leaves on the uppermost branch arising six inches below the cut surface were silvered, like-

wise the leaves of another branch somewhat lower. At the same time the end of the main stem was gumming. Silvering spread only slightly during the summer.

(11) As in (8) but kept as a control. On May 13th no silvering was apparent although the end of the stem was gumming; silvering did not develop later in the year.

Thus, apart from the control experiment, only three of the other inoculations failed to be followed by silvering. Each of the three inoculations carried out under conditions as sterile as possible, resulted in silvering although in one of them it was not the branch nearest the place of inoculation that became affected. In view of the experiments described below in regard to the cutting back of young plum trees without subsequent inoculation and which always remained healthy it is difficult not to connect the development of silver-leaf in the above trees with inoculation by spores of *Stereum purpureum*. Tree (No. 1) was cut down to the ground after the autumn of 1914 and the main stem was found to contain extensive discoloured zones of wood down to the base. Another feature of these experiments is the apparent lack of protection afforded by tar after exposure to the weather for two or three months.

Another series of experiments of the same kind was carried out during the winter of 1914–15.

The following are the details:

(1) The main stem of a bush Victoria, 4–5 years old, was cut back on November 20th, 1914, the surface being made smooth with a knife. On April 19th, 1915, a sporophore of *Stereum purpureum* from a silvered plum tree was suspended over the cut surface and covered with a tube as in the experiments of the previous year. The fungus was removed a few days later and the tube replaced.

Silvering did not develop during the following summer.

(2) As in (1). No silvering.

(3) As in (1). No silvering.

(4) As in (1). No silvering.

(5) As in (1), but the cut surface was covered with white paint. No silvering.

(6) As in (5).

(7) As in (1), but the cut surface was covered with Stockholm tar. No silvering.

(8) As in (7), but the cut surface was covered with Stockholm tar. No silvering.

(9) As in (7). No silvering.

(10) As in (7). No silvering but there was gumming at the cut surface.

(11) As in (1), but the cut surface was charred with a hot iron. During the early summer silvering developed in a branch four inches below the cut surface and later in the season on another branch two inches lower. This tree recovered during 1916.

(12) As in (11). No silvering.

(13) As in (1), but the cut surface was covered with gas tar. During the summer one shoot arising three inches below the cut surface became heavily silvered, and other branches became affected later in the season. In 1916 the tree was generally silvered. In 1917 the tree began to die back and *Stereum purpureum* developed on the dead branches.

(14) As in (13). No silvering.

(15) As in (13). No silvering.

(16) As in (13). No silvering.

(17) As in (1), but the cut surface was covered with white paint and varnish. No silvering.

(18) As in (17). No silvering.

(19) A bush Victoria as before, cut back and tubed April 19th, 1915, under sterile conditions but not inoculated. A small amount of gum developed on the cut surface during May, but there was no silvering.

In addition, three other trees of the same kind were left wholly untreated.

In this series of experiments only two inoculated trees became silvered during 1915. This small proportion of successful inoculations may be accounted for, probably, by the much later date at which the inoculations were performed than in 1913–14.

As will be seen later, there is evidence that inoculations with *Stereum purpureum* are the more effective the longer they are carried out before the growing season.

A series of inoculation experiments will now be described in which portions of sporophores of *Stereum purpureum* were inserted into the wood of young Victoria plum trees at different dates from the middle of February until June. These experiments were conducted because it seemed from previous experience that the fungus was less likely to cause infection if inserted during a period of active growth of the host. Victoria plum trees were inoculated twice a week, one tree on each occasion, from February 16th to May 16th, and after that at weekly intervals until June 2nd. Three branches on a tree were usually inoculated.

The *Stereum purpureum* used for inoculation was obtained from a silvered plum tree about two months before the experiments began and was kept dry in the meantime. At the commencement of the inoculations the sporophores gave a copious spore deposit after being moistened, but as time went on the period required for the deposition of spores increased, so it was considered advisable to use larger pieces of sporophore in the inoculations in order to compensate for the possible diminution of vitality. All trees inoculated until April 26th became heavily silvered during the summer, but after that date, silvering developed only slightly or not at all in the inoculated branches, and in the latter case there was no change the following year.

This result is to be partly attributed to lessened vitality in the fungus, but also perhaps in part to greater resistance of the host during the period of active growth.

A number of inoculations with sporophores of *Stereum purpureum* have been performed by placing the fungus in the bark only and not in the wood. In other sporophore inoculations, the inoculating material has been placed in a wound made into the wood.

Of nine Victoria plum trees inoculated in this manner one winter six became silvered the following spring, and examination of the affected branches showed that the fungus had spread extensively into the wood from the bark. As was to be expected the progress of silvering was at first slower than in trees inoculated directly in the wood.

Another series of inoculations of young trees with portions of the sporophores of *Stereum purpureum* may be mentioned. In March, 1918, fifteen young Victoria trees were inoculated in this way and by July all of these, with one exception, had become silvered, whereas none of the controls became silvered.

Sporophores of *Stereum purpureum* from different sources—silvered plum trees, dead beech trees, and willow stumps have all been used for inoculation, but as the experiments published in 1913 (2) show, there is no difference in infectivity between *Stereum purpureum* obtained from sources associated with silver-leaf disease, and that obtained from woody material which has not been connected with this affection. As long as the sporophore is vigorous it almost invariably produces silver-leaf by inoculation of a Victoria plum tree whatever the origin of the fungus may be.

During 1915 some material of *Stereum purpureum*, from a silvered cherry tree and from broom bushes respectively, was sent to one of us from New Zealand by the kindness of Miss Piggott of Victoria College,

Wellington. Although this material gave no spore deposit on arrival it appeared otherwise to be in fair condition so it was used during August, 1915, to inoculate two Victoria plum trees, but the fungus was inserted too late to expect silvering to result the same year. Profuse gumming occurred at each place of inoculation later in the summer and in the spring of 1916, one of the branches inoculated with the fungus from a silvered cherry tree was silvered and another inoculated branch subsequently became affected, the two remaining inoculated branches of this tree remaining healthy. Neither of the four inoculations made in the other tree from New Zealand material obtained from broom bushes resulted in silvering. Although few of these inoculations were successful, probably on account of the low vitality of the sporophores, the results show that *Stereum purpureum* obtained from New Zealand is capable of causing silver-leaf in plum trees in this country and from this one would suspect that *Stereum purpureum* was a cause of silver-leaf in fruit trees in New Zealand.

Since paper II of this series(2) was published, many additional inoculations with pure cultures of *Stereum purpureum* have been performed and a large number of them, especially in Victorias and Czars, have been followed by silvering.

Pure culture inoculations of the Pershore plum are of some particular interest for it is well known that this variety is only very occasionally attacked by silver-leaf disease under natural conditions. Nevertheless, Pershore trees were readily infected with silver-leaf disease by inoculating their branches with a vigorous pure culture of *Stereum purpureum*. Young Victoria trees growing on Pershore stocks as easily succumbed to silver-leaf by the use of pure cultures of the fungus as Victorias growing on the usual stocks.

As regards relative infectivity of the pure culture, in our experiments it was immaterial in general whether the culture was derived from *Stereum purpureum* growing on a silvered tree or on some other substratum such as a dead willow stump. In carrying out experiments with pure cultures it is important that the fungus should be growing vigorously and that the inoculations should be performed during the winter or early in the year, otherwise silvering may fail to develop.

A considerable number of plum trees which became silvered after inoculation with sporophore or pure culture material of *Stereum purpureum* developed fructifications of *Stereum purpureum* as the trees were killed.

With Koch's postulates thus carried out, it is difficult to look upon

such a result except as a convincing proof of the causal connection of *Stereum purpureum* with silver-leaf disease in these cases. As has been pointed out previously, the fructifications of *Stereum purpureum* usually only develop on the stems of silvered trees as they die back, and it is unusual for the fungus to form its fruit bodies earlier than a year after inoculation although, where infection was particularly rapid, *Stereum* appeared occasionally within a shorter period. In one tree *Stereum* developed within seven months of inoculation but in this instance the fungus arose exceptionally on one side of a branch which had been killed by the fungus while the other side of the branch was still healthy.

Spencer Pickering (8) has shown that plum trees which have recovered from silver-leaf are as liable to re-infection as trees which have not previously been infected by the disease. Our experiments in this connection gave the same result.

Attempts have been made to induce silvering by inoculating leaf stalks with small portions of the sporophores or with mycelium grown in pure culture. Nearly every leaf inoculated in this manner and most of the leaves wounded as controls, fell off soon after the operation, but the few leaves which remained attached after inoculation did not become silvered. Leaves of both plum (Victoria and Monarch) and apricot were used for this purpose.

Many inoculation experiments on plum trees with other species of *Stereum* in addition to those described in 1913 have been performed but with the exception of two doubtful successes with *Stereum spadiceum* (one sporophore, the other pure culture material) without silvering being induced. In both of these, the inoculated trees were old, and it was not possible to trace definitely the connection between the inoculation and the incidence of silvering. A suspicion exists that these trees became naturally infected.

None of the inoculations of young plum trees carried out with *Stereum rugosum*, *Stereum hirsutum*, and *Stereum spadiceum* were followed by silvering although there was sometimes a certain amount of gumming at the places of inoculation. In these experiments both natural sporophores and pure cultures were used but with the same negative result. Some of the branches inoculated in this way were subsequently cut up, and investigation showed that the fungus had spread in the tissues much less than when *Stereum purpureum* was the species used for inoculation.

(*b*) *Experiments with apple trees.*

As recorded in 1913 (2) few inoculations of apple trees with *Stereum purpureum* have resulted in silver-leaf. Three other trees of the Lord Suffield variety became silvered after inoculation with sporophores of *Stereum purpureum*, but other varieties (Lane's Prince Albert, Stirling Castle, Bramley's Seedling) inoculated either with sporophore or pure culture material of this fungus or with sporophores of *Stereum hirsutum* have remained unsilvered.

Reference has already been made (2) to the frequency of silvering in scions of regrafted apple trees in fruit plantations. We have had apple trees regrafted in order to keep them under observation in this connection: seven Bramley Seedling trees, and five Stirling Castle trees about five years old were cut back and regrafted in different ways with scions of Bramley Seedling either at the end of the main stem or in lateral branches.

An interval of a month elapsed between the cutting back of the stocks and the insertion of the scions which had been heeled into the ground for some time before use. After insertion of the scions, all exposed surfaces were covered with grafting wax. Most of the scions developed and formed healthy shoots during 1913 and 1914 but one of them became silvered during the summer of 1915. At the same time four old apple trees (two Codlin, one Warner's King, one French Crab) were regrafted with scions of Bramley Seedling. It is worth while to consider these trees in detail.

(1) *Codlin.* Seven scions of the twelve inserted grew well during 1913 the foliage being normal. By June, 1914, however, some leaves of each scion were silvered and the affection became more clearly marked as the summer advanced. During March, 1915, the upper parts of this tree bearing the scions were cut off in order to see if there was any considerable discolouration of the wood. This was present in quantity and up to distances of nearly a foot from the point of insertion of the scions.

There were several places from which the disease may have spread in the tissues. The exposed ends of the stock after the grafting wax had fallen off, dead scions, and the scars made by cutting away lateral branches below the scions, were all centres from which a fungus may have spread into the neighbouring tissues. The zones of discolouration relating to these areas often ran into one another and it was impossible

to determine with which of these the greatest amount of diseased wood was associated.

Portions of the affected branches were cut up and placed on moist sand and fructifications of *Stereum purpureum* developed on several of them within two months. During the summer of 1915, *Stereum purpureum* developed in abundance on the cut end of the stump of this tree remaining in the ground and nearly all the shoots arising from it were silvered.

(2) *Warner's King.* Fifteen scions were inserted in various ways and, of these, ten developed normally during 1913, the other five dying. During 1914 six of these living scions became silvered, the foliage of the others remaining normal. Portions of the tree were cut down in March, 1915, and the distribution of discoloured wood investigated, with the same result as in the tree just described. *Stereum purpureum* developed on some of these portions after being kept on moist sand for two months.

(3) *Codlin.* Eleven scions of Bramley Seedling were inserted, of which six developed normally during 1913 and 1914, the others dying. During 1915 the foliage of five of the scions became silvered.

(4) *French Crab.* Nineteen scions of Bramley Seedling were inserted of which thirteen developed normally during 1913, 1914, and 1915, the others dying.

In these regrafted trees the evidence points to *Stereum purpureum* as the cause of silvering, though it is by no means certain that this fungus is always the cause of silvering in regrafted apple trees.

It is obvious that, in regrafting operations, there is considerable opportunity for the entrance of a wound parasite like *Stereum purpureum*, but regrafted apple trees which become silvered often rapidly grow out of the malady.

In the trees referred to above, the character of the silvered leaves was the same as in plum leaves typically silvered. Thus the upper epidermis could be readily stripped off and the mesophyll cells had a tendency to fall asunder when sections were cut.

(*c*) *Inoculation experiments with other plants.*

Other kinds of woody plants have been inoculated with *Stereum purpureum* to see whether silver-leaf could be induced in them by this means. The following have been inoculated with success by inserting into the stem small pieces of sporophores: cherry (old trees), red currant (fructifications of *Stereum purpureum* subsequently developed on one

of the silvered bushes), horse chestnut, Philadelphus, and in gooseberry bushes by using mycelium grown in pure culture, although with these plants (cherry trees excepted) the percentage of successful inoculations was much less than in plum trees. Where inoculation was followed by silvering it was found that the fungus made considerable progress in the tissues, but in the unsuccessful inoculations the fungus grew very little. In 1913 certain inoculations of young cherry trees were described and it was pointed out(2) that the small branches experimented with were usually killed outright without an opportunity for silvering to become manifest, but in the successful inoculations now mentioned older branches were used for the experiments with the result that several became silvered.

On the other hand, the following plants have been inoculated with *Stereum purpureum* without silvering resulting: black currant, beech, elm, sycamore, cherry laurel and Portugal laurel. As regards the laurels, other species, e.g. *S. rugosum* and *S. spadiceum*, have also been used as the inoculant, but without success. All these plants, on several of which silvering has been occasionally seen in nature, were young and of vigorous growth and possibly therefore particularly resistant to invasion by the fungus. Inoculated branches which were examined showed that the fungus had made little advance in the tissues.

4. Attempts to induce silvering of foliage other than by inoculation with *Stereum purpureum*.

Various attempts have been made to induce silver-leaf in plums without the intermediary of *Stereum purpureum*, and although these have given generally negative results some are worthy of mention.

Attention was first directed to the possibility of inducing silver-leaf by injecting into the woody parts of healthy Victoria plums a sterile extract of wood known to be attacked by *Stereum purpureum*, the assumption being that the extract would be carried up to the leaves by the transpiration current where it might cause silvering. The extract was rendered sterile, except for the minutest viruses, by filtering it through a Chamberland bougie. The injection was carried out in the field by two different methods:

(*a*) In the lower part of the main stem by boring a hole, in which a cork traversed by a glass tube was placed, the latter being connected by rubber tubing to a reservoir situated three to four feet above and containing the extract. The joints were sealed with plasticine and air was excluded from passing into the stem.

(*b*) One of the main roots was severed and the cut end was immediately connected by tubing to a reservoir placed as above. This was found to be the most satisfactory method.

Apart from one tree, silvering was not induced by injecting an extract in this way, and the results being almost entirely negative, one is dubious about claiming that this single tree became silvered on account of injection.

Cut shoots of healthy Victoria plums placed in a similar extract during March and kept as far as possible under sterile conditions, developed their buds normally and the leaves did not become silvered.

Various other substances have been injected into Victoria plum trees in the hope that thereby silvering might be induced, but without success.

Efforts have also been made to induce silvering by checking or otherwise altering the transpiration current. Thus young Victoria plum trees have been drastically root-pruned, branches have been snapped nearly asunder during spring, and the stems of young trees have been cut back so as to leave only a few buds to develop, without silver-leaf developing.

5. FURTHER OBSERVATIONS ON THE MANNER OF INFECTION IN FRUIT PLANTATIONS.

Our views in this respect have undergone no material change since the publication of the second paper of this series in 1913, in which by far the most important cause of silver-leaf disease in the fruit plantations of this country was considered to be the fungus, *Stereum purpureum* acting as a parasite which entered through wounds in the stems and branches of the trees.

The possibility of root infection was not excluded where diseased roots came in contact with healthy ones or where roots became exposed and wounded from some cause or other, but we have not yet observed any trees, which indubitably became infected in this way. Wounds made during grafting or budding are an obvious source of danger. Plum trees in an advanced state of the disease often throw up suckers which are silvered on account of the passage of the fungus into the subterranean parts and Hector(6) has stated that in some parts of Middlesex such silvered suckers have been used as stocks upon which Victoria and other varieties were "worked." It is clear that if a silvered sucker used as a stock contained discoloured wood bearing the mycelium of *Stereum purpureum* there would be a probability that the scion would also become attacked. It by no means follows, however, that silvered

suckers arising from diseased trees necessarily contain discoloured wood themselves and, if they do not, there is no reason why these suckers used as stocks should not grow out of the malady.

The practice of using silvered suckers as stocks cannot be condemned too strongly, but it is not one which reliable nurserymen would follow under any circumstances. In our own experience we have only rarely seen plum trees under five years of age silvered and the danger of the disease being spread from reputable nurseries in the manner described above is probably negligible.

It is not usually until a plum orchard is in full bearing that silver-leaf plays havoc on an extensive scale even with the most susceptible varieties. From the age of twenty years onwards is the most critical time, and, as has been pointed out in the earlier papers, single branches of trees are usually first attacked, the earliest trees to become affected being scattered in the plantation.

If the first trees to be attacked are neglected and allowed to die back with the result that fructifications of *Stereum purpureum* develop, other trees adjacent to these may fall a prey with the result that groups become affected and simulate an attack by a root parasite which spreads through the soil.

As is well known, the variety Victoria is the most susceptible to silver-leaf disease of all plums grown in this country, and perhaps the variety Pershore is the most resistant. It has been thought that the former variety was particularly susceptible perhaps on account of the frequent breaking of the branches through overloading with fruit, thereby providing wounds for the fungus to enter. This idea is, however, invalidated by the remarkably brittle character of the old branches of the Pershore plum, trees of which are often built up, as it were, anew, by the development of young branches from the lower parts of the tree. In mature plantations of Victoria and Pershore plum there would probably be more wounds available for *Stereum purpureum* in the latter than in the former. The explanation of the special susceptibility of the variety Victoria is probably more subtle and is more likely to be found in some difference in the character of the wood itself. In horticultural parlance, the Victoria is known as a soft-wooded, and the Pershore as a hard-wooded variety, and this difference in texture, which signifies much, is probably concerned in this matter.

6. EXPERIMENTS ON THE CURATIVE TREATMENT OF SILVER-LEAF DISEASE.

It was pointed out in 1913(2) that in the state of our knowledge then, the only practicable means of control of the disease in fruit plantations lay in the excision of silvered branches and the eradication of trees which were beginning to die back. These measures and the results obtained by their application on a large scale will be referred to later in this paper. The present section deals with experiments of a chemical or quasi-chemical nature made in an attempt to seek a cure by medical rather than by surgical means.

Various workers have stated from time to time that they have cured silver-leaf in fruit trees by certain forms of manurial or chemical treatment, but upon enquiry it has been found that the number of trees so treated has been small and sometimes one only. It is also now well known that silvered trees not infrequently recover without treatment of any kind, so that the value of experiments conducted with small numbers of trees, especially where adequate controls are not kept, is doubtful. The extent of natural recovery varies considerably from year to year, but in our experience it was most marked in 1915 when a considerable number of the plum trees used in these investigations recovered naturally.

For the most part, the plum trees experimentally treated as described below, were in a moderately silvered condition as a result of inoculation by *Stereum purpureum*, although none of them had begun to die back at the time of treatment.

(*a*) *Treatment with artificial manures.*

In the *Gardener's Chronicle* for August 16th, 1913, "Southern Grower" stated that the application of artificial manures had caused the partial or complete recovery of several plum trees in one of his older plantations. During the winter of 1913–14 the root systems of five silvered trees in our plots were treated each with two pounds of a mixture of two parts superphosphate, one part sulphate of ammonia, and one part muriate of potash, the amount applied being less than that used by "Southern Grower" as the trees were younger. In 1914 none, and in 1915 one, of these trees recovered, although in the latter year several other untreated trees became healthy.

Four other trees heavily dressed with farmyard manure, two receiving a second application, showed recovery only in one.

Of five additional trees treated with both farmyard manure and two pounds of sulphate of iron each, applied to the roots, one recovered two years after treatment. The use of sulphate of iron in this connection will be referred to shortly.

Thus there does not appear to be any reasonable prospect of amelioration by manurial treatment, and, as is well known, the free use of nitrogenous manures often has the effect of making plant tissues specially susceptible to fungoid diseases.

(*b*) *Treatment with sulphate of iron.*

The application of this substance, both as a dressing applied to the roots and by plugging it into the stems was dealt with in the previous paper of this series (2). The roots of four additional trees were treated each with two pounds of this substance, two of them receiving a second application, but all became worse instead of better. The experiments in plugging silvered plum trees with sulphate of iron carried out by Mr E. Neaverson near Wisbech, were described in a preliminary way in 1913 (2), and through his kindness we are enabled now to give the final results of this experiment conducted by him. Of thirty-seven slightly affected trees plugged in 1910, twelve recovered during 1911, but by 1917 all of these had again succumbed to the disease some, indeed, so badly, that they had been felled together with others which had not recovered after treatment. Badly silvered trees plugged at the same time showed no recovery. As some slightly silvered trees in the same plantation also recovered without treatment, the above figures indicate that the application of ferrous sulphate to silvered trees in this way is not likely to be successful. When the treated trees were felled, it was ascertained that the sulphate of iron had disappeared and had presumably been absorbed into the tissues. Its toxic properties would doubtless kill some of the fungus in the wood though probably only in a limited zone. To ensure all parts of a tree containing the mycelium of *Stereum purpureum* being permeated by a solution of ferrous sulphate sufficiently strong to kill the fungus without seriously affecting the living cells of the tree would be very difficult, and is likely to be more completely effected by absorption through the roots than by the method just described.

(*c*) *Treatment with the fruit-bodies of Coprinus.*

In 1913 Miss Baker announced in the *Annals of Botany* that she had cured a silvered branch of a Victoria plum by injecting into it a

concentrated aqueous extract of the deliquescing fruit-bodies of *Coprinus*, the idea prompting this treatment being that the mycelium of *Stereum purpureum* might be digested, as it were, by the extract seeing that the fructifications of *Coprinus* undergo autodigestion. Miss Baker carried out only one experiment in this connection and there was no "control." To test this matter further, six silvered trees were injected by us with ripe fruit bodies of a species of *Coprinus* during 1913, holes being bored into the main stems, in which the fungus was inserted and sealed up. In the following year none of the trees had recovered and two were in a dying condition. In 1915 two of the treated trees recovered, but it is to be noted that this was the year in which a large number of healthy untreated trees likewise regained a healthy appearance.

(*d*) *Treatment with other antiseptics.*

Reference has already been made to the plugging of the stems of silvered trees with ferrous sulphate. Other antiseptic substances, e.g. salicylic acid, have been used on a limited scale in the same way, but without success.

In view of Ehrlich's work in medical therapy, the effect of an injection of neo-salvarsan was tried upon two silvered plum trees in the spring of 1914. Holes were bored into these trees towards the base of the stem and ·06 gram of this substance dissolved in 5 c.c. distilled water was poured into each, the holes being afterwards sealed with plasticine. Two injections were made in one tree and one in the other. The tree injected once did not recover, but in the one which was given two doses, the upper leaves wilted soon after the unfolding of the buds and the top of the tree died; this was probably due to the neo-salvarsan being too concentrated. The lower branches of this tree recovered on the other hand, and other healthy shoots subsequently arose. It is likely that the fungus in this tree was killed by the injection of neo-salvarsan, but a considerable part of the tree also was killed in the process.

Preliminary experiments on the injection of dilute solutions of certain aniline dyes into the branches of a large plum tree having shown a possibility of success by treatment with these substances, further trials of a more careful nature were made. For this purpose, the main roots of the trees to be experimented with were exposed at about the time of the opening of the buds; one, two or three of the roots were then severed and at once connected by means of tubing with reservoirs

containing a dilute solution of the dye, placed at a higher level. The exposed portions of roots were enclosed with slates which were readily removable if the roots required attention. At first, absorption of the solutions was rapid, and when it slowed down, the severed ends of the roots were pared, thus allowing absorption again to become vigorous. Dilute solutions of the following dyes were used for this purpose; Congo Red, Gentian Violet, Eosin, Methyl Violet and Methylene Blue. It was not expected that the last-named would prove toxic to the fungus as it is often used in dilute solution for *intra-vitam* staining, but, being a very clear stain, one thought it had the best chance of showing, by staining the wood, whether such dyes were carried to the extremities of the trees. The exact strength of these dyes in the transpiration current cannot be given for obvious reasons, but it was considerably less than 1 in 2000, as the solutions were made up at a strength of 1 in 2000 or 1 in 10,000. The results were as follows:

(1) *Eosin.* Of four treated trees, two recovered although some of the young leaves withered in one of these. A third tree showed partial recovery but some of the leaves were killed. The remaining tree showed no improvement.

(2) *Methyl Violet.* One tree recovered but two others showed no improvement.- None of the leaves were killed.

(3) *Congo Red.* The only tree treated with this became healthy. None of the leaves were killed.

(4) *Gentian Violet.* As for Congo Red.

(5) *Methylene Blue.* One tree recovered and one remained silvered. None of the leaves were adversely affected by this dye.

(6) *Control.* One tree in which distilled water was absorbed in the same way did not recover.

In the trees which absorbed these dyes, the xylem of the leaf petioles, especially the lower ones, became stained after a time, methylene blue being most evident, although it could not be detected in the uppermost leaves of the trees. The recoveries in these experiments were more numerous than have ever been observed by us to occur naturally, and it is likely that some at any rate were due to these dyes acting toxically on the fungus without seriously affecting the host. At present, these results are only of scientific interest, and until treatment of this kind has been applied on a larger scale, much importance cannot be assigned to it. From the practical point of view nothing can be done at present along these lines as the methods here used are too troublesome and too costly. If, however, certain of these dyes could be obtained at a cheap

rate, modified methods of injecting trees invaded by fungi in the wood, might be tried with some prospect of success.

While the above experiments were being carried out with dyes, other toxic substances also were injected in the roots of silvered trees in the same way, but with little or no success. Of two trees injected with a weak solution of ferrous sulphate (made up 1 in 1000) one doubtfully recovered and the other remained silvered. Solutions of corrosive sublimate and quinine sulphate (made up 1 in 1000) were without effect. Sodium arseniate, on the other hand, made up at the same strength, had a rapidly toxic effect upon the injected tree and although the strength of the solution was quickly reduced to 1 in 20,000 all the leaves withered except on one branch low down on the side away from the place of injection. These leaves remained silvered but by the following year all the upper part of the tree was dead and only a few sucker shoots, which were healthy, remained.

7. TREATMENT IN FRUIT PLANTATIONS.

In the light of the foregoing statement it will be recognised that there is at present no known *curative* treatment for this disease that can be applied on a commercial scale with prospect of success. The only sound method of control is along the lines advocated in the previous paper and advised in the leaflets recently issued by the Board of Agriculture. Where silvered branches have been properly cut back and dying trees have been grubbed so that *Stereum purpureum* is not allowed to fructify in the plantations, the disease has been kept under control and its spread has been so greatly checked that it has ceased to be a menace in some of the largest commercial plum gardens in the country, in which silver-leaf disease was formerly common. On the other hand, if the fungus is allowed to fructify with impunity the disease spreads with alarming rapidity in Victoria plums.

The following table kindly supplied by Mr E. Neaverson is an illustration of the rapid spread of silver-leaf disease in a Victoria plum plantation near Wisbech, even where conditions were not specially favourable for the extension of the disease. Some of these trees were plugged with sulphate of iron as described earlier in the paper and the most severely affected trees were cut down each winter though *Stereum purpureum* often developed on them before the trunks were removed from the plantation:

	1910	1911	1912	1913	1914	1915	1916	1917	1918
Number of trees standing	154	128	108	100	87	73	67	49	40
Healthy trees	74	78	69	60	50	37	29	23	16
Trees slightly affected	40	21	18	18	17	20	20	15	17
Trees badly diseased	40	29	21	22	20	16	18	11	7

Practical details in regard to the application of the methods here mentioned are given in the leaflets of the Board of Agriculture and need not be repeated here. It is admitted that hygienic measures of this kind are troublesome to carry out but they are commercially profitable and offer the only present means of successfully combating one of the most menacing fruit diseases.

It is likely that any measures which conduce to the general well-being of the trees will tend to reduce the danger of this disease, but these are not sufficient without the application of the means of control outlined above.

Fruit growers must be educated to look upon the fungus *Stereum purpureum* as a dangerous enemy wherever it occurs in the vicinity of fruit plantations, and they must deal with it accordingly.

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